Choices from the Past

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As something of an outsider to this group, I am going to take the liberty of offering you a story from my "tribe," which is made up of historians and sociologists of the history of science and technology. One of the big questions in this tribe has to do with the relation between scientific knowledge and the culture that creates it. As we learn more about the actual circumstances that led to past scientific innovations, we become aware of the larger than expected role of serendipity, luck and ambiguity. Scientists increasingly look like architects of truth rather than mere discoverers and collectors of facts. And if this is an accurate portrayal of what scientists are, then one might reasonably expect that different cultures develop different ways of solving scientific and technical problems and, in some cases, might disagree with other cultures about which facts are real and which are spurious.

In our graduate program at MIT, we have a number of students working on some variation of this problem. One of them, Slava Gerovitch from the former Soviet Union, is studying the differences in the ways Russians and Americans have defined the field of artificial intelligence. He has found that although both Russian and American scientists "based their AI (artificial intelligence) models on their understanding of the process of *human* thinking, taking it as something homogenous, ahistorical and natural, the "humans" that they took as universal categories were, in fact, people who belonged to specific cultures." Thus, Americans and Russians approached problem-solving differently, and so understood the world in fundamentally different ways. And, most importantly, their models of intelligence were different.

Slava offered several examples. In America, predictability and causality are treated as social norms: when you go into a restaurant, you typically do what the waiter expects and the waiter typically does what you expect, as if you are both following a script. This predictability is also built into computers (it is called causal chaining inference rules) and people's expectations of causality are met in a culturally identifiable way. For Russians, on the other hand, it is difficult to follow such a script, or even to describe "normal" life. They are more inclined to describe life in terms of risks and unexpected emergencies. As Slava describes it, "people have to take risks because the environment is irregular, but it is irregular precisely because everyone is taking risks. Under these circumstances, any planning is impossible." Slava points out that, for an American in Russia, making an appointment to see someone only slightly

improves one's chances of actually having such a meeting, rendering the ubiquitous American appointment book rather useless. Thus, where models of intelligence in the U.S. tend to be roughly linear, in Russia they tend to be roughly branching. Slava's other example of different problem-solving techniques focuses on the notion of choice. Americans are inured to the reality of making hundreds of choices every day from millions of options (grocery shelves, multiple-choice exams, quadraplex movie theaters, menus, department stores, etc.). But for Russians who go shopping, "the problem was not how to choose, but how to find anything at all." Indeed, where Americans view choice as a sacred right, Russians refer to choice as a burden. Where "Americans are accustomed to have such a wide range of alternatives that it is commonly perceived as a complete set of *all* possibilities, the main problem is merely to make the right choice." Russians "deal mostly with a narrow spectrum of alternatives and usually perceive it as inherently incomplete. They feel it necessary to widen the spectrum, to create a new, yet unknown, solution." I came upon an example of this very thing recently when reading about Americans who advised the Soviets on collectivization in 1929. Mordecai Ezekiel, a young farm economist in the U.S. Department of Agriculture (USDA), described efforts to teach Russian peasants how to thresh soybeans using a combine. He wrote, "One of the American specialists suggested how to set the teeth in the cylinder and adjust the speeds to do the job properly. Later he found the machine set as had seemed right to the workers, running full blast and churning the beans into an excellent imitation of soybean-oil butter. Again the workers announced proudly that they had discovered something. No one had ever had the idea of threshing beans with a combine—they were the first on earth to try it. The engineer's statements that it had been done for twenty years in America and could be done with the same combine far better than they were doing it, fell on deaf ears. The Russians thought they had discovered something new under the sun—and both the joy and the arrogance of discovery was theirs." Returning to AI modeling, then, while the Russian would be more comfortable with models that emphasize creative solutions to emergencies, the Americans would prefer a predictable sequencing of events. Neither model would be natural or universal to the other.

While Slava's notions of scientific thinking may seem far afield from biotechnology, I would like to suggest that these ideas of predictability and choice can help us think more critically about biotechnology, and particularly about its historical context. As a historian observing the emergence of agricultural biotechnologies, I have been struck by the way in which the discourse regarding the meaning of each new innovation is generally ahistorical; that is, both researchers and critics seem unaware of the scientific, technical and social precedents for the innovation. The particular characteristics of each innovation—hybrid corn's high yield, bovine somatotropin's (bST) increased production of milk, Flavr Savr's™ longer shelf-life—are emphasized, while its institutional and political relationship to earlier innovations is ignored. I do not mean to

suggest that all such innovations were dreamed up by the same company or university, or that they are directly linked in any way. Rather, my point is that they all represent a generally singular pattern of relationships between federal research laboratories, corporate sponsors, individual scientists, regulatory agencies, universities and the public. Further, these relationships are historically grounded in institutional developments, so that scientific products are functionally quite similar despite their wildly different characteristics. While Flavr Savr™ tomatoes and hybrid corn might seem totally unrelated, they were both made possible, and some might say predictable, by virtue of the negotiations and collaborative arrangements that were set up with the Hatch Act of 1887 and the Adams Act of 1906—acts that defined the public good not in a misty-eyed, Jeffersonian America but in a steely-eyed, Gilded Age America.

While time does not permit a full-scale discussion of these arrangements, I would like to highlight the way in which such institutional deals served to push agriculturalists to model themselves on nonagricultural areas of science and engineering with the result that agriculture now finds itself stuck between the Scylla of the public and the Charibdys of the research establishment. As a way of illustrating this trend, I will consider how public and private choices in agriculture have been increasingly reduced over the years, despite the general feeling that we have an overabundance of choices. To do this, we will venture beyond the sphere of biotechnology per se because the historical precedents come from some surprising directions.

Looking at the trajectory of scientific and technological developments over the last hundred years, one is immediately struck by the trend towards making nature more rational, simple, tractable and more amenable to human control and understanding. In the life sciences this has been called "reductionism" and refers to the fact that since the turn of the century and the rediscovery of Mendel's laws, biologists have been inclined to study ever smaller increments of life and to extrapolate their findings to larger forms of life. One particularly striking example of this was the idea, developed in the first decade of this century, that if genes were responsible for the inheritance of such things as eye color and stature in humans, then they must also be responsible for the inheritance of other human traits such as alcoholism, lewdness, atheism or simple idiocy. The eugenists, as scientists who believed this were called, also believed that more promising characteristics were likewise inherited, such as high intelligence, kindness and good health. This was an attractive philosophy to those well-bred members of the scientific community who were uncertain how to manage the growing immigrant population, urban overcrowding and the increasing tendency of some to challenge the elite and its privileges. And eugenics was attractive because it promised a course of action, a capability for change, as had all successful scientific paradigms. If social and psychological characteristics were heritable, the logic went, then people with good characteristics should have lots of children and people with bad characteristics should not. By the early 1920s many states had passed laws allowing mental

institutions to sterilize adolescents exhibiting such traits as feeblemindedness, epilepsy and promiscuity.

This reductionist approach was also operative in the drive to create hybrid corn in the 1920s. As the first biotechnological artifact, hybrid corn seemed to promise a much simplified commodity, a plant that had predictable and uniform features, that would harbor no nasty surprises, and that would look and act the same anywhere, anytime it was planted. The notion that Mendelian genetics led to all kinds of new corn plants hid the fact that, in their effort to create specialized plants that fit a niche for, say, short seasons or deep roots, scientists reduced both the strains available and the features of each strain. But the reductionism was not merely biological. Institutionally, USDA-sponsored institutions quit funding research on open-pollinated plants by the mid-1920s, confident that hybrids were the wave of the future and that maintaining and crossing open-pollinates would be a waste of time. By 1940, seed companies like Funk Brothers did not even offer open-pollinates for sale. While we are all aware of the genetic difficulties this caused in later years, I want to emphasize that the reduction of research capabilities through funding cuts, organizational changes and institutional realignments had just as tragic an effect. The pattern was established where new discoveries yield not an increased number of options for researchers, but a decreased number of options because the new *replaced*, rather than joined, the old.

While these new scientific forms grew out of the new Mendelian predictive capabilities, they also reflected broader trends in agricultural thinking. With the end of World War I, agricultural markets for American farm products closed with a bang. The ensuing farm depression was the most severe on record. With farm costs high, prices low and a flood of products on the market, thousands of farmers lost their farms and lots of banks and insurance companies found themselves owners of farms. Agricultural leaders such as Henry A. Wallace were perplexed: how to stabilize agriculture, how to guarantee farmers a fair profit, how to control the amount of corn or wheat or hogs farmers produced each year? For urban leaders, however, the answer was clear—make farming industrial. In their minds, there was nothing inherently rational or orderly about manufacturing either; however, J. J. Hill and Henry Ford and Thomas Edison had made it rational. The same should be done for farming, the last great romantic form of production.

The move towards large-scale farming in the 1920s was born of this belief that simplicity, rationality and standardization were proper ideals for agriculture, and that the manufacturing arena was a proper model. In manufacturing, this trend was fairly recent and involved replacing craft production with machine production. For example, before the 1910s most of the metal trades were still dominated by highly skilled craftsmen who fashioned each part on a piece by piece basis, hired and fired their own assistants, owned their own tools, followed their own work rules and kept their own hours, which of-

ten seemed anarchic to factory managers. When corporate observers were admiring Henry Ford's Highland Park assembly line in 1915, they were impressed not only with the number of cars Ford could produce, but with the way Ford had all but eliminated skilled and unionized workers from his shop, replacing them with unskilled immigrants and skilled machines.

While to us the differences between agriculture and manufacturing appear rather obvious, they were seen as challenges to be overcome by enthusiastic urbanites such as John D. Rockefeller and J. P. Morgan who financed some of the largest experiments in industrial farming. Weather was a real problem, but farmers need not just accept Nature's variations and impediments which, with a little ingenuity, could be made less troublesome. Just as Ford had economized by making only one kind of car, farmers could grow just one crop, such as wheat or oranges. Rather than worry about lack of rainfall in the West, farmers should consider changing Nature itself with massive irrigation projects. Rather than settling for Nature's parsimonious arrangement of fields, farmers could fill ditches, cut trees, flatten hillsides and join fields together to make a smoother tableland on which to operate big combines. Rather than relying on unreliable laborers, farmers should invest in such machinery. And, of course, farmers who were not very skilled in this new agriculture should consider some other line of work.

So-called corporate farms sprang up all over the place. Some were characterized by their vastness such as Thomas Campbell's 95,000 acre wheat ranch in Montana. Campbell had been trained as an engineer, not as a farmer, and produced wheat much as Henry Ford produced cars. He installed time clocks on his tractors and ran machinery three shifts a day around the clock. He was the model of the new agriculture, a hardheaded businessman who believed that farming was a productive enterprise, not a romantic way of life. Other examples of corporate farms included a livestock farm in Texas that boasted four towns, churches, a hospital, schools, roads, electricity and running water in workers' houses—in short, everything a skilled industrial worker could want. Other examples were a mint farm in Michigan, a turkey farm in California, wheat farms in Kansas, and so on.

One of the reasons for this sudden interest in industrialized farming had to do with the role of banks and insurance companies, which found themselves owning farms but not really knowing what to do with them. Desperate to improve these farms for resale, many such institutions hit upon the idea of hiring agricultural extension agents from the colleges and setting them up as farm managers. Such agents found that they could manage ten or twenty farms if they could simplify and rationalize operations across the board. It was simply too much work to treat each farm as an isolated and intrinsically unique entity; if they could be thought of as units of one big farm organization, or if their needs could be made similar to each other, then the job of managing them was much easier. Within a few years the field of farm management was created as a subset of farm economics.

Coming back to Slava's discussion of choice and his notion of the "burden of choice," one can understand how the variation and choice of a farmer's field and home became a bank's "burden of choice," and why an institution might wish to radically reduce the variations and choices a client might have. This has long been a country bank's prerogative. In Montana, for example, the agricultural experiment station designed a scorecard for bankers to use when deciding whether to loan money to farmers in 1930. Linking risk with modernity, bankers were encouraged to loan money to farmers who had expanded their acreage, purchased new machinery, electrified their homes and practiced monoculture. In such a scenario, farmers were not troubled with too many choices. If history is any indicator, bankers in dairy states will have a modern version of this scorecard very soon.

Those of you who spend your time thinking about the future of agricultural science and technology, then, should beware the seduction of thinking that we, as citizens, are awash in choices. Selecting a plain old tube of toothpaste at the drugstore can be a paralyzing and stupefying experience thanks to the ridiculous number of options. But these are trivial options and their absence would not represent anything very important. We need to be concerned about the actually important options, the fruitful relationships that have forged between citizen groups, federal researchers and policymakers, scholars and donors, and so on. We need to be certain to keep old strategies available, for example, to students who will think of new applications for them, or for corporate sponsors who get bloodied on the cutting edge. We need to be careful to keep old solutions, as well as old problems, available, to recognize creativity both at the lab bench and in the field, and to reward innovation, both material and magical.